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In re Patent Application of: Michael J. O'Phelan
Title: FLAT CAPACITOR HAVING AN ACTIVE CASE
Attorney Docket No.: 279.235US1

PATENT APPLICATION TRANSMITTAL

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UNITED STATES PATENT APPLICATION

FLAT CAPACITOR HAVING AN ACTIVE CASE

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FLAT CAPACITOR HAVING AN ACTIVE CASE

Cross-Reference to Related Applications

This application is related to Application Serial Number xx/yyyyyy (Docket 5 # 279.234us1), filed on an even date herewith, entitled FLAT CAPACITOR FOR AN IMPLANTABLE MEDICAL DEVICE, which is incorporated herein by reference in its entirety.

Technical Field

The present invention concerns implantable medical devices, such as 10 defibrillators and cardioverters, and more specifically to a method of manufacturing a capacitor for an implantable heart monitor.

Background

Since the early 1980s, thousands of patients prone to irregular and 15 sometimes life-threatening heart rhythms have had miniature heart monitors, particularly defibrillators and cardioverters, implanted in their bodies, typically in the upper chest area above their hearts. These devices detect onset of abnormal heart rhythms and automatically apply corrective electrical therapy, specifically one or more bursts of electric current to the heart. When the bursts of electric current are 20 properly sized and timed, they restore normal heart function without human intervention, sparing patients considerable discomfort and often saving their lives.

The typical defibrillator or cardioverter includes a set of electrical leads, which extend from a sealed housing into the wall of a heart after implantation. Within the housing are a battery for supplying power, monitoring circuitry for 25 detecting abnormal heart rhythms, and a capacitor for delivering bursts of electric current through the leads to the heart.

The capacitor can take the form of a flat aluminum electrolytic capacitor. Flat capacitors include a stack of flat capacitor elements mounted within a capacitor case. Each flat capacitor element includes one or more separators between two

sheets of aluminum foil. One of the aluminum foils serves as a cathode (negative) foil, and the other serves as an anode (positive) foil. Sometimes, two or more foils are stacked one on the other to form a multi-anode stack. The capacitor elements each have an individual capacitance (or energy-storage capacity) proportional to the 5 surface area of the aluminum foil.

One drawback with these capacitors is that they consume significant space within the implantable defibrillators and cardioverters and thus limit how small these devices can be made. However, the size of the capacitor cannot be arbitrarily reduced without reducing the capacitance of the device. Accordingly, there is a 10 need to reduce the size of the capacitor while also maintaining or increasing its capacitance. Further, there is a need to provide a compact capacitor capable of providing the required pulse of energy for use within the device and to provide for a design efficiently utilizing space within the capacitor case.

15

Summary

In one aspect, the present invention provides a capacitor having an active case. In one embodiment, the active case comprises a cathodic case. In another embodiment, the active case comprises an anodic case.

One aspect provides a capacitor having an active cathodic case which 20 services an adjacent anode. In one embodiment, a capacitor includes a case having an etched inner surface, the inner surface including an etched upper inner surface and an etched lower inner surface. The capacitor further includes a capacitor stack disposed within the case, where the capacitor stack includes a plurality of cathode stacks and a plurality of anode stacks, and the cathode stacks are electrically coupled 25 with the etched inner surface. The plurality of anode stacks include a first anode stack disposed adjacent to the upper inner surface, where the first anode stack includes at least one conductive layer having a major surface. The major surface confronts the upper inner surface of the case. The capacitor further includes

electrolyte disposed between the upper inner surface and the major surface to facilitate charge storage between the inner surface and the major surface.

In one embodiment, a method includes forming and aligning a capacitor stack including at least one anode stack and at least one cathode stack, etching at

- 5 least a portion of an inner surface of a capacitor case, the inner surface including an upper inner surface and a lower inner surface. The method further includes disposing the capacitor stack in the capacitor case, and at least one anode stack is adjacent the inner surface of the capacitor case. The method also includes disposing an electrolyte between the at least one anode and the inner surface of the case.

10 One aspect provides a capacitor having an active anodic case. In one embodiment a capacitor assembly includes at least one anode stack having one or more anode conductive layers and an anode separator, and at least one cathode stack having one or more cathode conductive layers and a cathode separator. The capacitor assembly further includes at least one separator disposed between the 15 anode stack and the cathode stack, where each at least one anode stack stacked with the cathode stack to form a capacitor stack, and a capacitor case sized to receive therein the capacitor stack. The capacitor case includes a conductive surface therein, and one or more of the anode conductive layers is electrically coupled with the conductive surface of the capacitor case.

20 In one embodiment, the capacitor case comprises an etched capacitor case. In another embodiment, the assembly includes a cathode feedthrough coupled with at least one cathode stack, where the cathode feedthrough extends through and is insulated from an opening of the case. In yet another embodiment, one or more of the anode conductor layers includes an exposed edge coupled with the capacitor 25 case. In one embodiment, each of the cathode conductive layers is defined in part by a cathode edge surface, and each of the anode conductive layers is defined in part by an anode edge surface, where the cathode edge surface is offset from the anode edge surface. The assembly optionally further includes a welded connection disposed between at least one of the one or more anode conductive layers and an

inner surface of the case. The assembly optionally further includes a conductive epoxied connection disposed between at least one of the one or more anode conductive layers and an inner surface of the case.

Among other advantages, in one or more embodiments, an active anodic case contributes to the effective anodic surface area which increases the capacitance of the capacitor without increasing the outer packaging dimensions. Alternatively, it allows for achievement of a given total capacitance with a smaller package. An active cathodic case provides that an outer cathode layer is not needed on the capacitor stack to service the anodes. This decreases the size of the capacitor. A further benefit is that since the edge of the cathode stack is offset from the anode stack, damage or puncturing of the separator layer is minimized.

These and other embodiments, aspects, advantages, and features of the present invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art by reference to the following 15 description of the invention and referenced drawings or by practice of the invention. The aspects, advantages, and features of the invention are realized and attained by means of the instrumentalities, procedures, and combinations particularly pointed out in the appended claims and their equivalents.

20

Brief Description of the Drawings

Figure 1 is an exploded perspective view illustrating a capacitor as constructed in accordance with one embodiment.

Figure 2 is an exploded perspective view illustrating a capacitor stack as constructed in accordance with one embodiment.

Figure 3 is an exploded perspective view illustrating an anode stack as constructed in accordance with one embodiment.

Figure 4 is an exploded perspective view illustrating a cathode base layer as constructed in accordance with one embodiment.

Figure 5 is a cross-sectional view illustrating a portion of a capacitor as constructed in accordance with one embodiment.

5 Figure 6 is an exploded perspective view illustrating a capacitor stack as constructed in accordance with one embodiment.

Figure 7 is an exploded perspective view illustrating a cathode stack as constructed in accordance with another embodiment.

10 Figure 8 is a cross-sectional view taken along 8 - 8 of Figure 9 illustrating a portion of a capacitor as constructed in accordance with one embodiment.

Figure 9 is a top plan view illustrating a capacitor as constructed in accordance with another embodiment.

15 Figure 10 is a top plan view illustrating an anode as constructed in accordance with one embodiment.

Figure 11 is a perspective view illustrating a capacitor stack as constructed in accordance with one embodiment.

Figure 12 is a perspective view illustrating a capacitor stack as constructed in accordance with one embodiment.

20 Figure 13 is a perspective view illustrating a capacitor stack as constructed in accordance with one embodiment.

Figure 14 is a cross-sectional view illustrating a portion of a capacitor as constructed in accordance with one embodiment.

Figure 15 is a cross-sectional view taken along 15-15 of Figure 9 illustrating a portion of a capacitor as constructed in accordance with one embodiment.

25 Figure 16 is a block diagram of an implantable heart monitor system constructed in accordance with one embodiment.

Description of the Embodiments

In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced.

5 These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural changes may be made without departing from the scope of the present invention. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of the present invention is defined by
10 the appended claims and their equivalents.

Figure 1 illustrates a flat capacitor 100 in accordance with one embodiment of the present invention. Capacitor 100 includes a case 110, which contains therein a capacitor assembly 108, which includes a capacitor stack 150. Case 110 is an active case. “Active case” means herein that case 110 is, in various embodiments,
15 anodic or cathodic. In one option, the case 110 is manufactured from a conductive material, such as aluminum.

In one embodiment, the case 110 is generally D-shaped, and is sized to receive the capacitor stack 150 therein. In other embodiments, the capacitor 100 can take on other shapes and configurations, including, but not limited to,
20 rectangular, circular, irregular, oval, or other symmetrical or asymmetrical shapes.

The capacitor stack 150 includes anode stacks 200 and cathode stacks 300, with separator layers interposed therebetween, as is further discussed below. The capacitor stack 150 further includes a connector 130 which connects, in one embodiment, the cathode stacks 300 with active case 110. In another
25 embodiment, connector connects anodes 200 to the active case 110.

The case 110 further includes two components, a cover 118 and a bottom 120, which are coupled together as part of the assembly process. In one option, the cover 118 and the bottom 120 are welded together.

By providing an active case, wherein the case acts as an anodic element or a cathodic element, the capacitor 100 can be made smaller while delivering the same amount of energy.

5

Active Cathodic Case Embodiment

In one embodiment, the present invention provides a capacitor having an active cathodic case which services adjacent anodes. As used herein, "service" means that the case is cathodic in the sense that it not only is connected to the cathode stacks but literally services the anodes which are adjacent to the case. This 10 means the case itself replaces one or two of the end cathodes which are usually present on the two outermost elements of the capacitor stack.

In this embodiment, case 110 is comprised of at least 98% aluminum. Case 110 has an inner surface 112 which includes an upper inner surface 114 and a lower inner surface 116. At least a portion of the inner surface 112 is etched, and in one 15 option, the entire inner surface 112 is etched. In one example, the inner surface 112 of the case 110 is etched in the same way that a cathode conductive layer 320 (Figure 5) is etched.

Figure 2 illustrates one example of the capacitor stack 150 in greater detail. The capacitor stack 150 includes a plurality of capacitor elements 160, each 20 capacitor element 160 includes at least one anode stack 200, at least one separator 170, and one or more cathode stacks 300. In this embodiment, one of the cathode stacks is a cathode base layer 305.

Capacitor stack 150 also includes an end anode stack 202 and an end separator 172 which confront an inner surface 112 of case 110 (Figure 1) when 25 stack 150 is mounted within case 110.

Each cathode stack 300 is interconnected with the other cathode stacks in the capacitor stack 150 and with base cathode layer 305. The interconnected cathode stacks are electrically coupled with the case 110 through connection member 120 of base cathode layer 305. In this embodiment, case 110 is an active

part of the cathode, as will be discussed further below. In one embodiment, a cathode stack is used as described in co-pending application xx/yyyy (Docket # 279.248) entitled FLAT CAPACITOR HAVING MULTI-TAB FOIL LAYERS, filed on an even date herewith, and incorporated herein by reference in its entirety.

5 Other embodiments include aluminum tabs attached to each cathode layer. The tabs are connected together and connected to case 110.

Separator 170 and 172 include, but are not limited to, two sheets of paper separator. The separators are, in one option, made from a roll or sheet of separator material. Suitable materials for the separator material include, but are not limited 10 to, pure cellulose or Kraft paper. Other chemically inert materials are suitable as well, such as porous polymeric materials. The separator layers are cut slightly larger than the anode layers (or cathode layers) to accommodate misalignment during the stacking of layers and to prevent subsequent shorting between electrodes of opposite polarity.

15 The interconnected cathode stack is electrically coupled with the case 110 (Figure 1) which has an etched inner surface 112 (Figure 1). Capacitor stack 150 includes an end anode stack 202. Having an end anode stack 202 which is serviced by the case 110 eliminates the need for outer cathode stacks. Since at least one cathode stack 300 can be removed, this results in a space savings of at least .0012 20 inches (an exemplary cathode thickness). Further, at least one less separator 170 is needed, resulting in savings of .0005 inches per side. In one embodiment, a second cathode stack is removed from the other end of the capacitor stack, resulting in an additional space savings of .0012 inches for the foil and .0005 for the separator. Thus, an exemplary space saving is 0.0017 inches per side and 0.0034 25 inches for the both sides. These space saving are variable in various embodiments depending on the thickness of foil used for the cathodes. Furthermore, the present capacitor provides for a simplified capacitor having fewer components.

Figure 4 illustrates an exploded view of the anode stack 200 according to one embodiment. The anode stack 200 includes an anode separator 210, at least

one conductive layer 220, and an edge connection member or edge clip 240 coupled with at least one of the conductive layers 220. In one option, the at least one conductive layer 220 includes a first conductive layer 222, a second conductive layer 224, and a third conductive layer 226. The first conductive layer 222 includes 5 a clearance portion 242 surrounding the edge clip 240. Each of the conductive layers 220 include a major surface 230 and a side surface 232.

Figure 5 illustrates an exploded view of cathode base layer 305 according to one embodiment. Cathode base layer 305 includes legs 324, the number of which and location of which are varied depending on the cathode stack 300. Legs 324 are 10 for interconnecting base layer 305 to the other cathodes 300 of the capacitor stack. Cathode base layer 305 includes a cathode separator 310 and a cathode conductive layer 320. In one embodiment, the cathode conductive layer 320 has an outer perimeter 322 inset from the cathode separator edges 312 so that the edge clip 240 (Figure 4) will not contact the cathode conductive layer 320. Since the outer 15 perimeter 322 is inset, this can help to prevent a discontinuity on an edge 228 of the anode stack 200 (Figure 4) from making contact with the conductive layer 320 of the cathode stack 300. This design also allows for more variations in tolerances which can occur during the manufacturing of the anode stack 200 and the cathode stack 300. Attached or integral with cathode 305 is connection member 120 for 20 attaching cathode 300 to case 110.

Figure 6 illustrates a cross-sectional view of the capacitor stack 150 within the case 110. Although the discussion relates to an upper portion of the case, the view of the capacitor stack is substantially the same for a lower portion of the case, and therefore is not repeated. The capacitor stack 150 includes one or more anode stacks 200, where each anode stack 200 includes, for example, a first conductive layer 222, a second conductive layer 224, and a third conductive layer 226. The anode stack 200 further includes an anode separator 210. The layers 222, 224, 226 of the anode stack 200 are coupled together. In one embodiment, the layers are staked together as described in co-pending application xx/yyyyy (Docket #

279.168) entitled FLAT CAPACITOR HAVING STAKED FOILS AND EDGE-CONNECTED CONNECTION MEMBERS, filed on an even date herewith, and incorporated herein by reference in its entirety.

The major surface 230 of the first conductive layer 222 of the first anode stack 204 faces the etched upper inner 114 surface of the case 110, separated from case 110 by separator 170. An electrolyte 180 is disposed between the major surface 230 and the upper inner surface 114. The electrolyte 180 facilitates a storage of charge between the anode stack 200 and the case 110. The etched upper inner surface 114 of the case 110 services the anode stack 200 in the same way that a cathode stack 300 services the anode stack 200. In one embodiment, the capacitor stack 150 includes a first anode stack 204 having a major surface 230 facing and adjacent the upper inner surface 114, and a second anode stack 206 (Figure 2) having a major surface 230 confronting the lower etched inner surface 116 (Figure 1), where the case 110 services both the first anode stack 204 and the second anode stack 206.

In one embodiment, an inner surface 250 of the edge clip 240 extends along the edges 228 of the second and third conductive layers 224, 226 of the anode stack 200. The inner surface 250 of the edge clip 240 also extends past the separator edge 212 and the cathode separator edge 312. The edge clip 240 also extends along the edge 212 of the anode separator of an adjacent capacitor element 160 until making contact and being connected with an adjacent edge clip 240. A plurality of edge clips stack on top of one another such that a bottom surface 244 of an edge clip 240 contacts a top surface 246 of an edge clip 240 of an adjacent capacitor element 160.

The edge clip 240 allows for greater design flexibility in the choice of materials for the anode conductive layers 220 as the conductive layers remain essentially flat while the connection between anode stacks 200 is made. In addition, the edge clip 240 assists in filling the cross section of the case with anodic surface area, and thus increases the overall percentage of space within the case

occupied by anodic surface area. This helps to increase capacitance of the capacitor, and/or allows for the capacitor to be made smaller.

Some embodiments omit edge clips 240, and interconnect the anode stacks 200 with tabs which are attached to or integral with each anode stack.

5 In one embodiment, edge clips 240 are interconnected and coupled to feedthrough 280 (Figure 1), which is insulated from case 110. In addition, the feed through opening 282 (Figure 1) is sealed.

One example of a method for forming a capacitor having an active cathodic case is as follows. The method includes forming and aligning a capacitor stack 10 including at least one anode stack and at least one cathode stack, etching at least a portion of an inner surface of a capacitor case, the inner surface including an upper inner surface and a lower inner surface. The method further includes disposing the capacitor stack in the capacitor case, and an at least one anode stack is adjacent the inner surface of the capacitor case. The method also includes disposing an 15 electrolyte between the at least one anode and the inner surface of the case.

Several options for the method are as follows. For instance, in one option, the method includes etching layers of the anode stack. In another option, the method further includes confronting a major surface of a first anode stack with the upper inner surface of the case. In yet another option, the method includes 20 confronting a major surface of a second anode stack with the lower inner surface of the case. Optionally, the method includes etching an entire inner surface of the case.

In another example of manufacturing the above described cathodic case 25 capacitor, a capacitor case is formed, including a case cover and a case bottom, and the inner surface of the capacitor case is etched. A stack of cathode and anode layers are stacked and aligned to form a capacitor stack. The cathode ledges are welded and folded over the stack. The capacitor stack is taped, and the anode edge clips are welded. An anode feed through is welded to the edge couplers. The

capacitor stack is inserted into the capacitor case, and the case cover and cathode leg extension is welded to the case bottom.

Advantageously, the etched inner surface of the case increases cathodic surface area on an existing surface. The etched inner surface allows for reduction 5 of cathode stacks within the case by allowing at least one outer cathode stack to be removed, which in turn allows for the size of the capacitor to be reduced. Alternatively, the anodic surface area within the case can be increased and the total capacitance of the capacitor can be increased.

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Active Anodic Case Embodiment

Another aspect of the present invention provides a capacitor having an active anodic case. Referring again to Figure 1, in one embodiment, case 110 comprises a 99.99% aluminum. In another embodiment, the case comprises at least 15 a 98% aluminum. In one embodiment, at least a portion of the inner surface 112 is etched, and in one embodiment, the entire inner surface 112 is etched.

Figure 6 illustrates a capacitor stack 650 according to one embodiment of the present invention. Capacitor stack 650 is mountable in case 110 similarly to stack 150.

In this embodiment, capacitor stack 650 includes a plurality of capacitor 20 elements 160, each capacitor element 160, except for the end capacitor elements, includes at least one anode stack 200, at least one separator 170, and at least one cathode stack 300. The capacitor stack 650 includes end separators 172. Each cathode stack 300 is interconnected with the other cathode stacks in the capacitor stack 650. Each anode stack 200 is interconnected with the other anode stacks in 25 the capacitor stack 650.

The at least one separator 170 and the end separator 172 include, but are not limited to, a paper separator. The separators are, in one option, made from a roll or sheet of separator material. Suitable materials for the separator material include, but are not limited to, pure cellulose or Kraft paper. Other chemically inert

materials are suitable as well, such as porous polymeric materials. The separators layers can be cut slightly larger than the anode layers (or cathode layers) to accommodate misalignment during the stacking of layers and to prevent subsequent shorting between electrodes of opposite polarity.

5 Referring again to Figure 3, in one embodiment, anodes 200 includes one or more conductive layers 220. Each of the conductive layers 220 include an outer edge surface 218, which define an outer edge of the capacitor stack 650 (Figure 6). In one option, the outer edge surface 218 of at least one of the conductive layers 220 is exposed and is electrically coupled with the inner surface 112 of the case 10 110 (Figure 1), as will be discussed further below.

Figure 7 illustrates an exploded view of a cathode stack 306 in greater detail. The cathode stack includes legs 324, the number of which and location of which is varied depending on the cathode stack 300. The cathode stack 300 includes a cathode separator 310 and a cathode conductive layer 320. The cathode 15 conductive layer 320 has an outer perimeter 322 inset from the cathode separator edges 312 so that the edge clip 240 (Figure 3) will not contact the cathode conductive layer 320. Since the outer perimeter 322 is inset, this can help to prevent a discontinuity on an edge 228 of the anode stack 200 (Figure 3) from making contact with the conductive layer 320 of the cathode stack 300. This 20 design also allows for more variations in tolerances which can occur during the manufacturing of the anode stack 200 and the cathode stack 300.

Figure 8 illustrates a cross-sectional view taken along 8 - 8 of Figure 9, which shows a capacitor 100. The capacitor stack 650 is disposed within the capacitor case 110. The inner surface 112 of the capacitor case 110 includes a dielectric 180 formed thereon. In this embodiment, the perimeter 174 of each 25 separator 170 and 172 contacts the inner surface 112 of the case 110. In addition, the outer perimeter 322 (Figure 7) of the cathode stack 300 is inset from the perimeter 174 of the separator 170. In one embodiment, the major surface 230 of the first anode stack 204 faces the etched upper inner 112 surface of the case 110.

Outer edge surface 218 of at least one anode stack 200 contacts the inner surface 112 of the case 110. In one option, the outer edge surface 218 is exposed and electrically coupled with the inner surface 112 of the case 110, for example, by intimate contact. In another option, the anode stack 200 is coupled with the inner surface 112 of the case 110 in other manners. For example, the anode stack 200 is coupled at 182 with the inner surface 112 by welding the anode stack 200 with the inner surface 112. In another example, the anode stack 200 is coupled at 182 with the inner surface 112 by bonding the anode stack 200 with the inner surface 112, for example, using epoxy or other bonding materials.

Figure 10 shows an anode 1001 having a tab connector 90 according to another embodiment. In this embodiment, one anode in capacitor stack 650 includes a tab connector 90. The other anodes in the capacitor stack are interconnected and tab connector 90 is coupled to case 110. In some embodiments, more than one anodes have tab connectors 90. In one embodiment, tab connector is welded to anode 1001.

Figure 11 illustrates a capacitor stack 650 including a cathode extension leg 328. In this embodiment, the cathode extension leg 328 extends from the bottom cathode stack 304 below the bottom edge clip 240. The cathode extension leg 328 is insulated from the edge clip 240 by an insulator 190 included on the inner surface of the cathode extension leg 328. The cathode extension leg 328 is folded over the edge clips 240 and coupled to a feedthrough 380 (Figure 1). After connection to the feedthrough 380, the exposed portion of the cathode extension leg optionally is insulated to prevent contact with the anodic case 110.

The cathode stacks 300 include cathode interconnect legs 324. In an alternative option, a feedthrough 380 (Figure 1) is coupled to one of the legs 324 and the remaining exposed portion is covered by insulator 192 (Figure 12).

Figures 12 and 13 illustrate the capacitor stack 650 where the anode stack 200 (Figure 6) is coupled with the case 110 (Figure 1). The capacitor stack 650 includes an anode extension leg 290 coupled to the outer contact surface of the

edge clips 240. The cathode extension leg 328 is folded over the anode extension leg 290 and is insulated from the anode extension leg 290 by insulator 190. The outer surface of the cathode extension leg 328 is suitable for receiving a feedthrough connection. After connection to a feedthrough, the exposed portion of the cathode extension leg 328 is insulated to prevent contact with the anodic case 110. The capacitor stack 650 includes insulator 192 over cathode interconnect legs 324.

Figure 14 illustrates a cross-sectional view of a portion of the capacitor stack 650. In this embodiment, the connection between the edge clips 240 and the case 110 is with the anode extension leg 290. The anode extension leg 290 is coupled to and extends from the interconnected edge clips 240. Each edge clip 240 includes an outer contact surface 248, which provides a larger contact surface that is more easily attached to an anode extension leg 290 than existing methods of attachment. The anode extension leg 290, in one option, is sufficiently ductile to be deformed to extend along the side of the capacitor stack 150 and between the interface between the case cover 110 and the case bottom 120. As mentioned above, the cathode extension leg 328 folds over the anode extension leg 290 and is insulated from the anode stacks (Figure 6) and anode extension leg 290 by insulator 190.

Figure 15 shows a cross-section of section 15-15 of Figure 9. The outer surface of the cathode extension leg 328 is coupled to a cathode feedthrough 380. An insulator 384 is included over the remaining exposed portion of the outer surface of the cathode extension leg 328. The cathode feedthrough 380 is welded to the outer surface of the cathode extension leg 328, and the cathode feedthrough 380 is insulated from the case 110 (Figure 1). The feedthrough opening 382 (Figure 1) is sealed.

One aspect of the present invention provides a method of manufacturing. In one embodiment, a method includes stacking at least one anode stack including one or more conductive anode layers and an anode separator, stacking at least one

cathode stack including one or more conductive cathode layers and a cathode separator, aligning and stacking the at least one anode stack and the at least one cathode stack to form a capacitor stack, disposing the capacitor stack within a capacitor case, and electrically coupling the anode stack with the capacitor case.

5 Several options for the method are as follows. For example, in one option, the method further includes etching an inner surface of the capacitor case, and/or etching the one or more conductive anode layers. In another option, the method further includes welding the anode stack with the capacitor case, or bonding the anode stack with the capacitor case. In a further option, the method further
10 includes coupling a cathode feedthrough with the cathode stack, and disposing the cathode feedthrough through an opening of the capacitor case. In another option, the method further includes stacking the conductive cathode layer in an offset position from the anode conductive layer, and/or exposing outer edges of the one or more conductive anode layers. In yet another option, the method further includes
15 coupling the exposed outer edges with the capacitor case, and/or welding the exposed outer edges with the capacitor case.

20 In another example of manufacturing the above described capacitor, a capacitor case is formed, including a case cover and a case bottom, and optionally the inner surface of the capacitor case is etched. A stack of cathode and anode layers are stacked and aligned to form a capacitor stack. The cathode legs are welded and folded over the stack. The capacitor stack is taped, and the anode edge clips are welded. An anode leg is welded to the edge clips, and the cathode feedthrough is welded to the cathode extension leg. The capacitor stack is inserted into the capacitor case, and the case cover and the anode extension leg are welded
25 to the case bottom. An anode ribbon is welded to the case, and the opening for the feedthrough is sealed.

Advantageously, having the case contribute to the effective anodic surface area increases the capacitance of the capacitor without increasing the outer packaging dimensions. Alternatively, it allows for achievement of a given total

capacitance with a smaller package. A further benefit is that since the edge of the cathode stack is offset from the anode stack, damage or puncturing of the separator layer is minimized.

5

Implantable Medical Device

Figure 16 illustrates one of the many applications for the capacitor assembly. For example, one application includes an implantable heart monitor 330 which provides therapeutic stimulus to a heart muscle, for instance, a defibrillator. The heart monitor 330 is coupled with a lead system 332. The lead system 332 is 10 implanted in a patient and electrically contacts strategic portions of a patient's heart. The heart monitor 330 further includes a monitoring circuit 334 for monitoring heart activity through one or more of the leads of the lead system 332. The heart monitor 330 further includes a therapy circuit 336 which includes one or more capacitors 338 having one or more of the features discussed above. The 15 therapy circuit 336 delivers a pulse of energy through one or more of the leads of lead system 332 to the heart, where the heart monitor 330 operates according to well known and understood principles.

In addition to implantable defibrillators, the capacitor can be incorporated into other cardiac rhythm management systems, such as heart pacers, combination 20 pacer-defibrillators, congestive heart failure devices, and drug-delivery devices for diagnosing or treating cardiac arrhythmias. Alternatively, the capacitor can be incorporated also into non-medical applications, for example, photographic flash equipment.

It is to be understood that the above description is intended to be 25 illustrative, and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reading and understanding the above description. It should be noted that embodiments discussed in different portions of the description or referred to in different drawings can be combined to form additional embodiments of the present invention. The scope of the invention should,

therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

What is claimed is:

1. A capacitor comprising:
 - an aluminum case; and
- 5 a capacitor stack mounted within the aluminum case, the capacitor stack comprising one or more anodes and one or more cathodes, one of the one or more anodes and one or more anodes attached to the aluminum case;
 - wherein the case is adapted to be an active capacitor element.
- 10 2. The capacitor of claim 1, wherein the case is etched and is adapted to be an active cathodic element servicing one or more anodes of the capacitor stack which are adjacent the case.
- 15 3. The capacitor of claim 1, wherein the case is adapted to be an active anodic element.
4. A capacitor comprising:
 - an aluminum case having an etched inner surface;
 - a capacitor stack disposed within the case, the capacitor stack including a
- 20 plurality of cathode stacks and a plurality of anode stacks, the cathode stacks electrically coupled with the etched inner surface; and
 - the plurality of anode stacks including a first anode stack disposed adjacent to the etched inner surface, the first anode stack having a major surface facing the etched inner surface of the case and having an electrolyte saturated separator
- 25 disposed between the etched inner surface and the major surface to facilitate charge storage between the etched inner surface and the major surface.
5. The capacitor as recited in claim 4, wherein the plurality of anode stacks include a second anode stack disposed adjacent to a lower inner surface, the second

anode stack including at least one conductive layer having a second major surface, the second major surface facing the lower inner surface of the case.

6. The capacitor as recited in claim 4, wherein the plurality of anode stacks
5 comprise etched anode stacks.

7. The capacitor as recited in claim 4, wherein the case comprises at least 98%
aluminum.

10 8. A method comprising:

forming and aligning a capacitor stack including at least one anode stack
and at least one cathode stack;

etching at least a portion of an inner surface of a capacitor case, the inner
surface including an upper inner surface and a lower inner surface;

15 disposing the capacitor stack in the capacitor case, and an at least one anode
stack is adjacent the inner surface of the capacitor case; and

disposing a separator between the at least one anode and the inner surface of
the case.

20 9. The method as recited in claim 8, further comprising etching layers of the
anode stack.

10. The method as recited in claim 8, further comprising confronting a major
surface of a second anode stack with the lower inner surface of the case.

25

11. The method as recited in claim 8, further comprising etching an entire inner
surface of the case.

12. An assembly comprising:
at least one lead adapted to apply electrical energy to patient;
a monitoring circuit adapted to monitor electrical function of a heart;
a therapy circuit adapted to deliver electrical energy through the at least one
5 lead, wherein the therapy circuit includes one or more capacitors, each including:
a case having an inner surface including an upper inner surface
and a lower inner surface:
a capacitor stack disposed within the case, the capacitor stack
including a plurality of cathode stacks and a plurality of anode stacks; and
10 the plurality of anode stacks including a first anode stack
disposed adjacent to the upper inner surface, the first anode stack including
at least one conductive layer having a major surface, the major surface
confronting the upper inner surface of the case; and
a separator between the upper inner surface and the major surface.
15

13. The assembly as recited in claim 12, the plurality of anode stacks including
a second anode stack disposed adjacent to the lower inner surface, the second anode
stack including at least one conductive layer having a major surface, the major
surface confronting the lower inner surface of the case.
20

14. The assembly as recited in claim 12, wherein the plurality of anode stacks
comprise etched anode stacks.
25

15. The assembly as recited in claim 12, wherein the case comprises at least
98% aluminum.

16. A capacitor assembly comprising:
at least one anode stack including one or more anode conductive layers and
an anode separator;

at least one cathode stack including one or more cathode conductive layers and a cathode separator;

at least one separator disposed between the anode stack and the cathode stack,

5 each at least one anode stack stacked with the cathode stack to form a capacitor stack; and

a capacitor case sized to receive therein the capacitor stack, the capacitor case including a conductive surface, and one or more of the anode conductive layers electrically coupled with the conductive surface of the capacitor case.

10

17. The capacitor assembly as recited in claim 16, wherein the capacitor case comprises an etched capacitor case.

15

18. The capacitor assembly as recited in claim 16, further comprising a cathode feedthrough coupled with at least one cathode stack, the cathode feedthrough extending through and is insulated from an opening of the case.

19. The capacitor assembly as recited in claim 16, wherein one or more of the anode conductor layers includes an exposed edge coupled with the capacitor case.

20

20. The capacitor assembly as recited in claim 16, wherein the one or more anode conductive layers is coupled to the capacitor case by an elongated tab.

25

21. The capacitor assembly as recited in claim 16, further comprising a welded connection disposed between at least one of the one or more anode conductive layers and an inner surface of the case.

22. The capacitor assembly as recited in claim 16, further comprising an epoxied connection disposed between at least one of the one or more anode conductive layers and an inner surface of the case.

5 23. The capacitor assembly as recited in claim 16, wherein the case comprises at least 98% aluminum.

24. The capacitor assembly as recited in claim 16, wherein the capacitor case comprises an etched capacitor case of at least 99.99% aluminum.

10

25. The capacitor assembly as recited in claim 16, further comprising at least one edge clip coupled with each of the at least one anode stack, and the edge clip is electrically coupled with an inner surface of the case.

15 26. A capacitor assembly comprising:

at least one anode stack including one or more anode conductive layers and an anode separator;

a capacitor case sized to receive therein the anode stack, the capacitor case including a inner conductive surface; and

20 means for electrically coupling the at least one anode stack with the inner conductive surface.

25 27. The capacitor assembly of claim 26, wherein means for electrically coupling comprises an elongated aluminum tab coupled to one of the at least one anode stacks.

28. A capacitor assembly comprising:

at least one anode stack including one or more anode conductive layers and an anode separator, the one or more conductive layers including an exposed outer anode edge;

5 at least one cathode stack including one or more cathode conductive layers and a cathode separator;

at least one separator disposed between the anode stack and the cathode stack,

each at least one anode stack stacked with the cathode stack to form a 10 capacitor stack;

an etched capacitor case sized to receive therein the capacitor stack, the capacitor case including a conductive surface, and the exposed outer anode edge electrically coupled with the conductive surface of the capacitor case;

a cathode feedthrough coupled with at least one cathode stack, the cathode 15 feedthrough extending through and is insulated from an opening of the case; and

each of the cathode conductive layers is defined in part by a cathode edge surface, and each of the anode conductive layers is defined in part by an anode edge surface, and the cathode edge surface is offset from the anode edge surface.

20 29. The capacitor assembly of claim 28, wherein the capacitor case comprises at least 99.99% aluminum.

30. A method comprising:

stacking at least one anode stack including one or more conductive anode 25 layers and an anode separator;

stacking at least one cathode stack including one or more conductive cathode layers and a cathode separator;

aligning and stacking the at least one anode stack and the at least one cathode stack to form a capacitor stack;

disposing the capacitor stack within a capacitor case; and
electrically coupling the anode stack with the capacitor case.

31. The method as recited in claim 30, further comprising etching an inner
5 surface of the capacitor case.

32. The method as recited in claim 30, further comprising etching the one or
more conductive anode layers.

10 33. The method as recited in claim 30, further comprising welding the anode
stack with the capacitor case.

34. The method as recited in claim 30, further comprising bonding the anode
stack with the capacitor case.

15 35. The method as recited in claim 30, further comprising coupling a cathode
feedthrough with the cathode stack, and disposing the cathode feedthrough through
an opening of the capacitor case.

20 36. The method as recited in claim 30, further comprising stacking the
conductive cathode layer in an offset position from the anode conductive layer.

37. The method as recited in claim 30, further comprising exposing outer edges
of the one or more conductive anode layers.

25 38. The method as recited in claim 37, further comprising coupling the exposed
outer edges with the capacitor case.

39. The method as recited in claim 38, further comprising welding the exposed outer edges with the capacitor case.

Abstract of the Disclosure

A capacitor comprising an aluminum case; a capacitor stack mounted within the aluminum case, the capacitor stack comprising one or more anodes and one or more cathodes, one of the one or more anodes and one or more anodes
5 attached to the aluminum case; wherein the case is adapted to be an active capacitor element. In one aspect, a capacitor includes a case having an etched inner surface, the inner surface including an etched upper inner surface and an etched lower inner surface. The capacitor further includes a capacitor stack disposed within the case, where the capacitor stack includes a plurality of cathode stacks and a plurality of anode stacks, and the cathode stacks are electrically coupled with the etched inner surface. The plurality of anode stacks include a first anode stack disposed adjacent to the upper inner surface. In one aspect, a capacitor assembly includes at least one anode stack having one or more anode conductive layers and an anode separator, and at least one cathode stack having one or more cathode conductive layers and a cathode separator. The capacitor assembly further includes at least one separator disposed between the anode stack and the cathode stack, where each at least one anode stack stacked with the cathode stack to form a capacitor stack, and a capacitor case sized to receive therein the capacitor stack. The capacitor case includes a conductive surface therein, and one or more of the anode conductive
10 layers is electrically coupled with the conductive surface of the capacitor case.
15
20

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Date of Deposit: November 3, 2000

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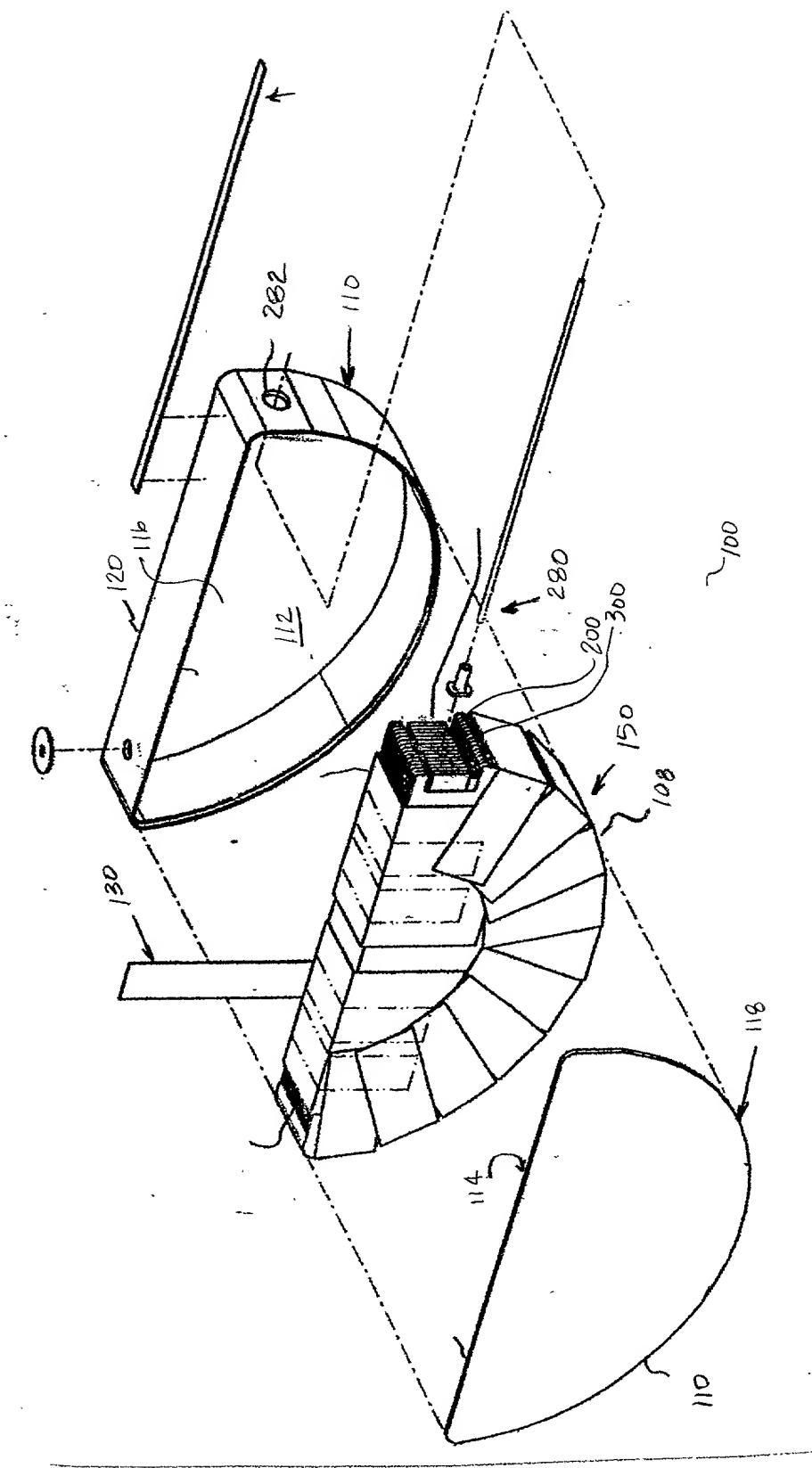


FIG. 1

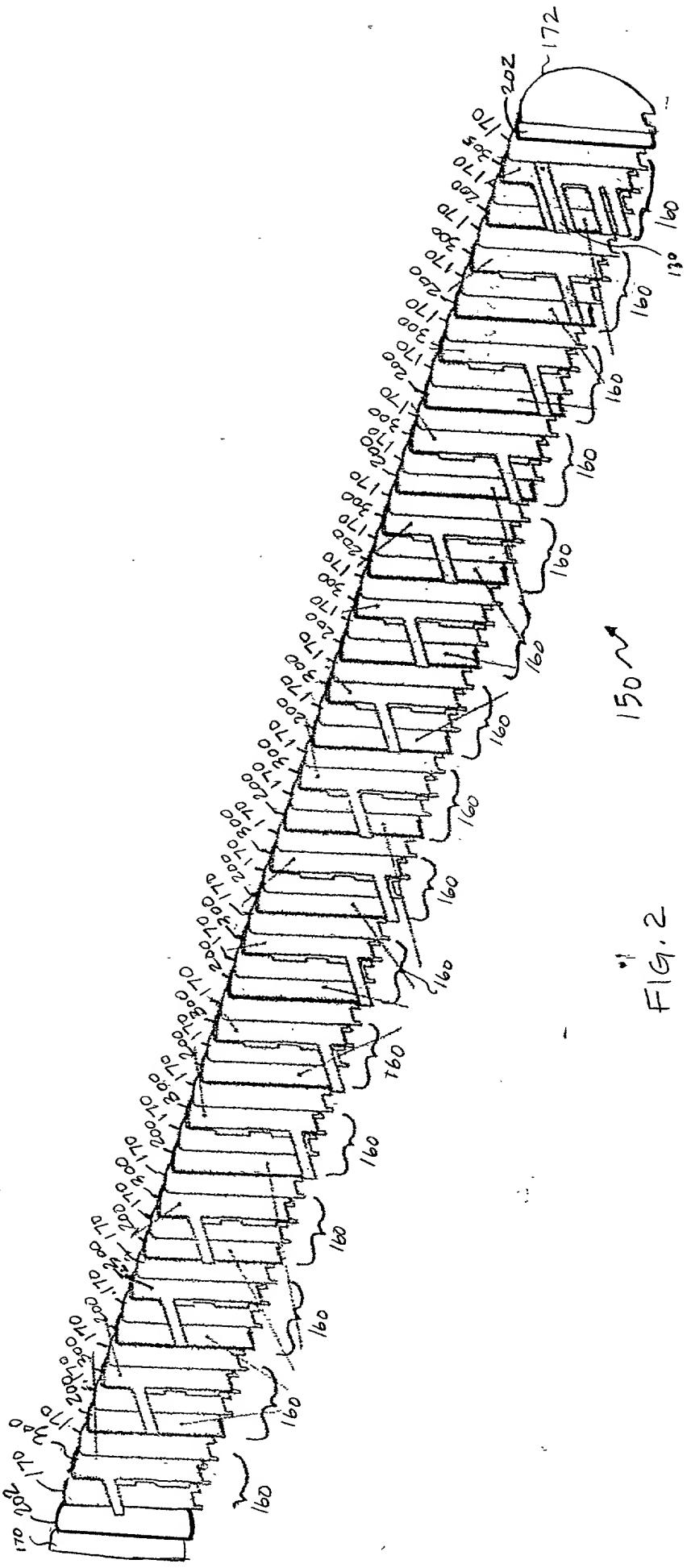


Fig. 2

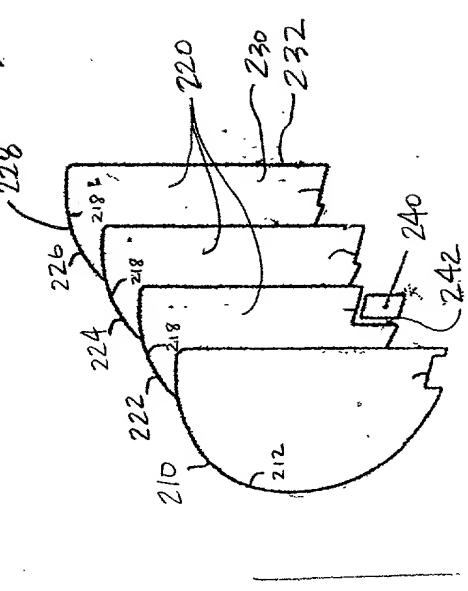


FIG. 3

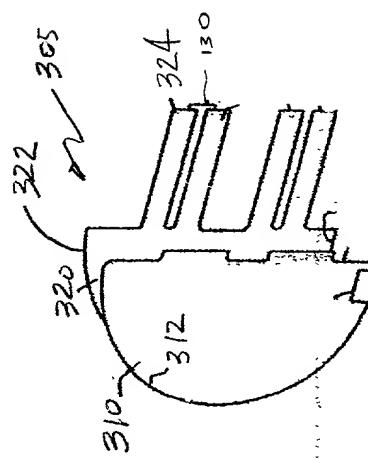


FIG. 4

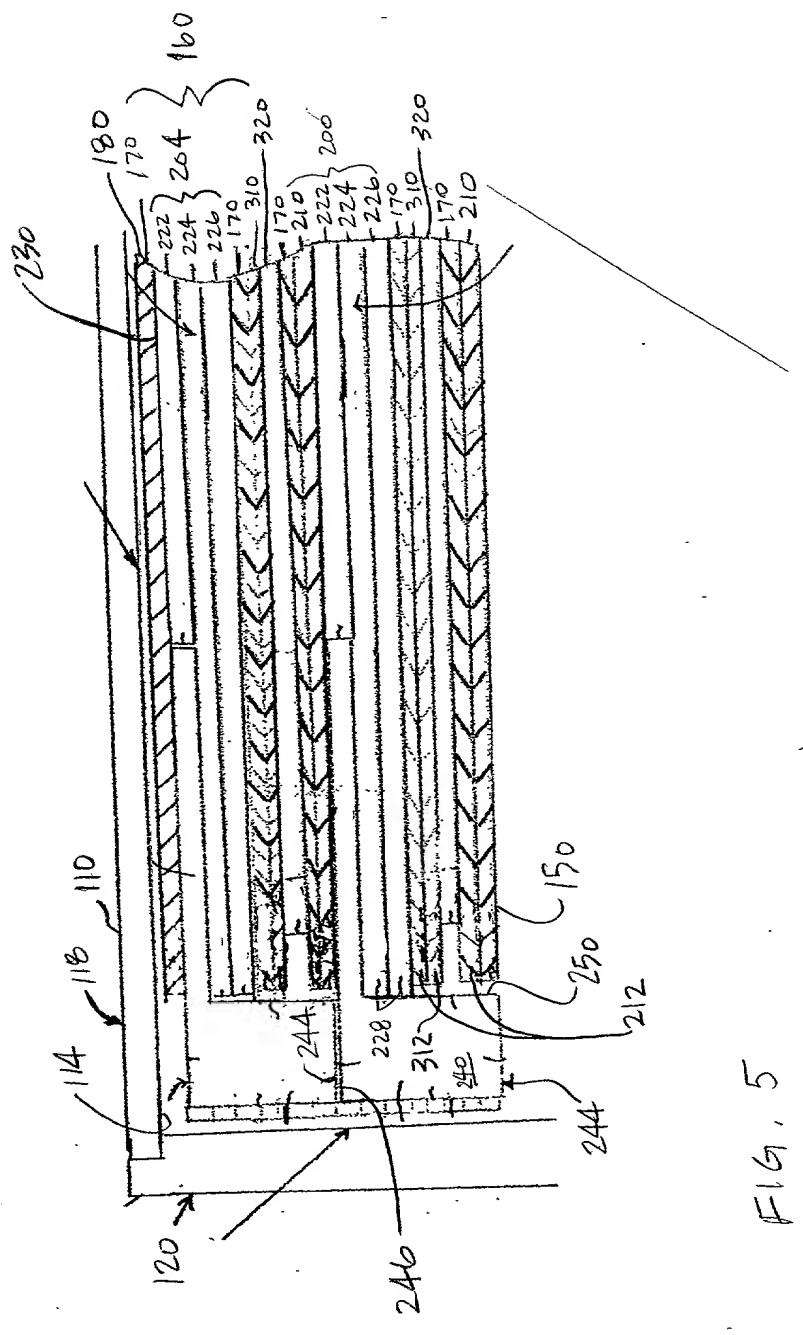


Fig. 5

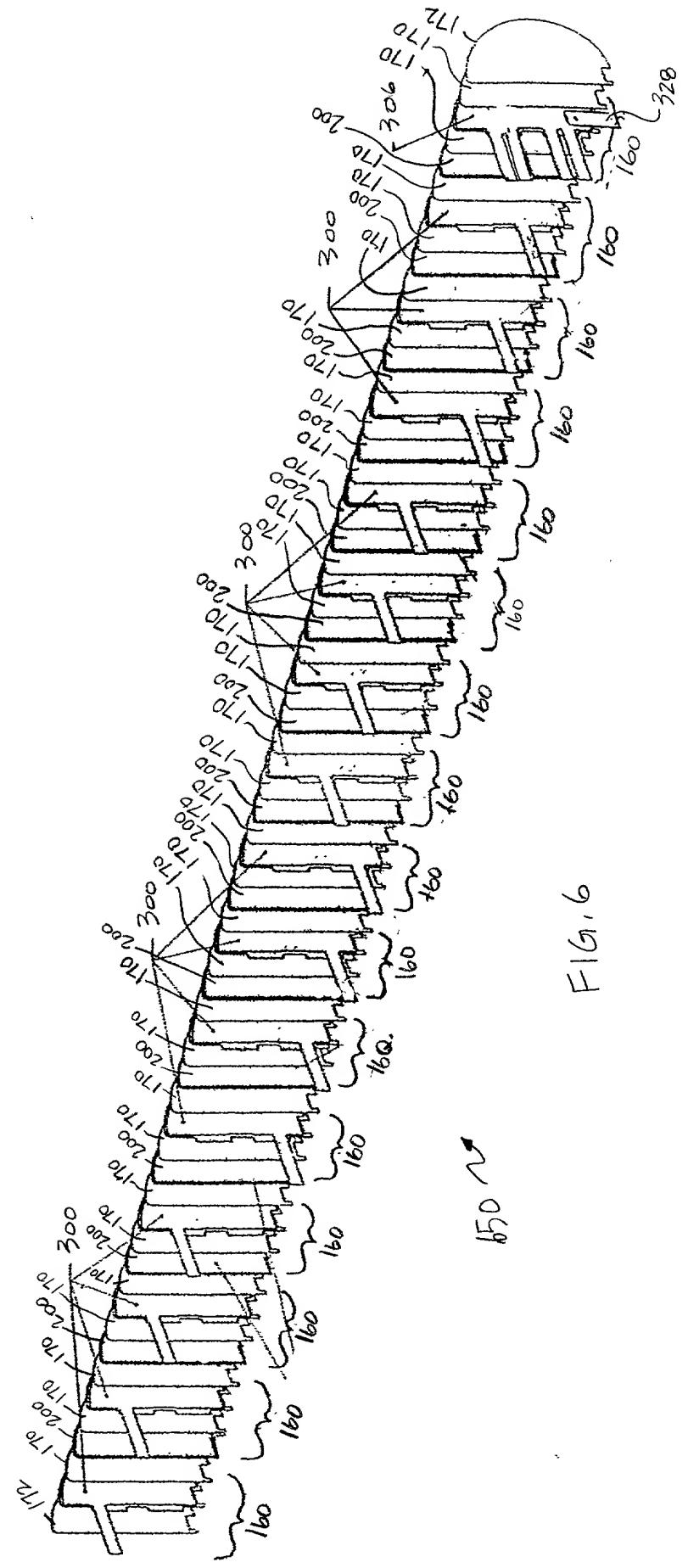


Fig. 6

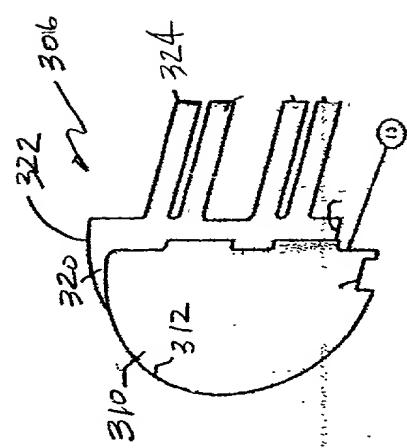


FIG. 7

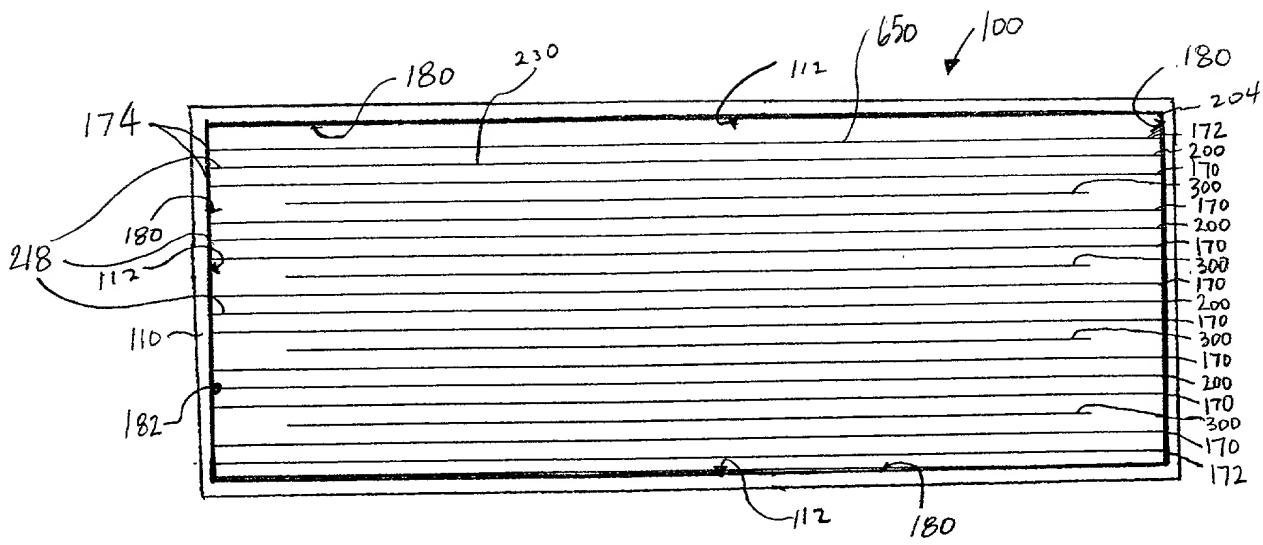


FIG. 8

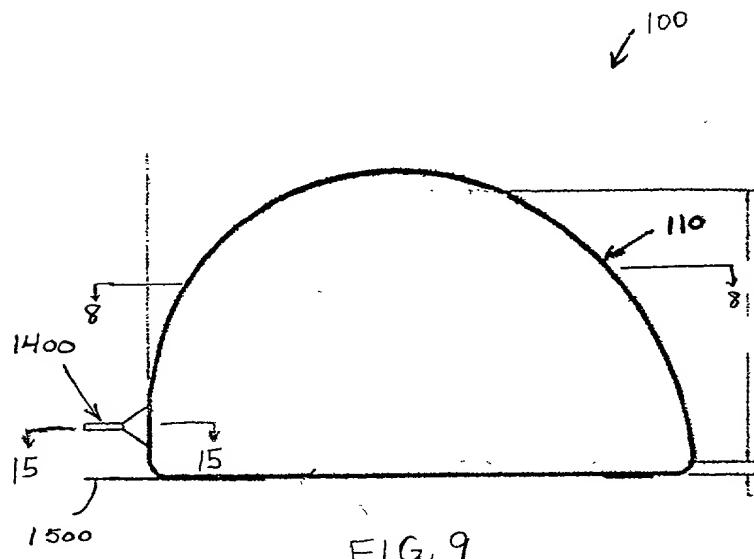


FIG. 9

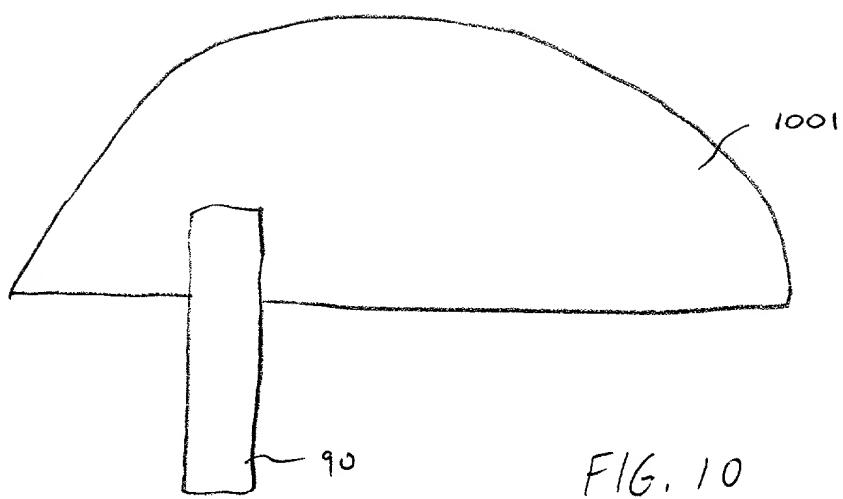


FIG. 10

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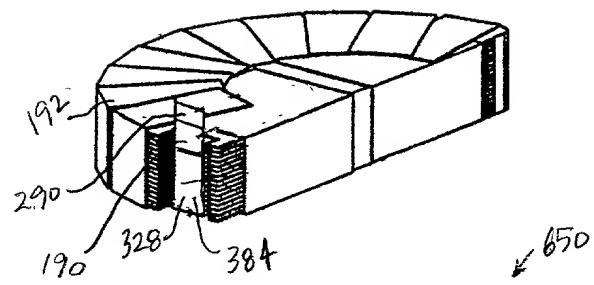


FIG. 13

650

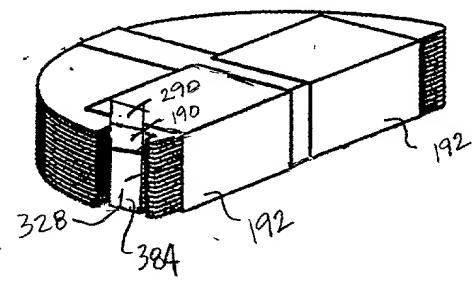


FIG. 12.

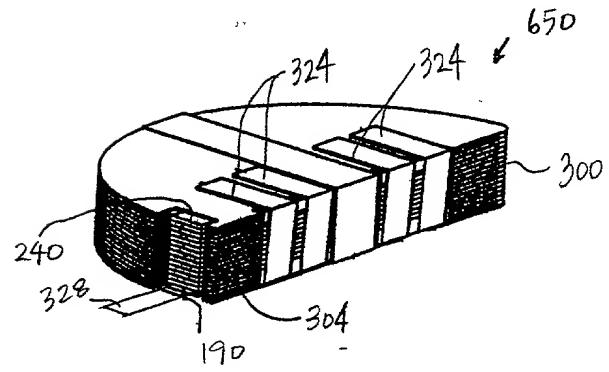


FIG. 11

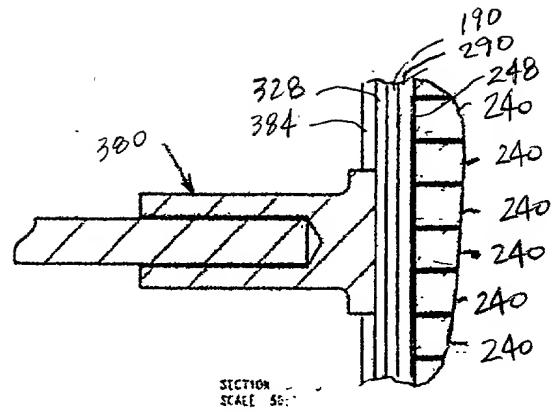
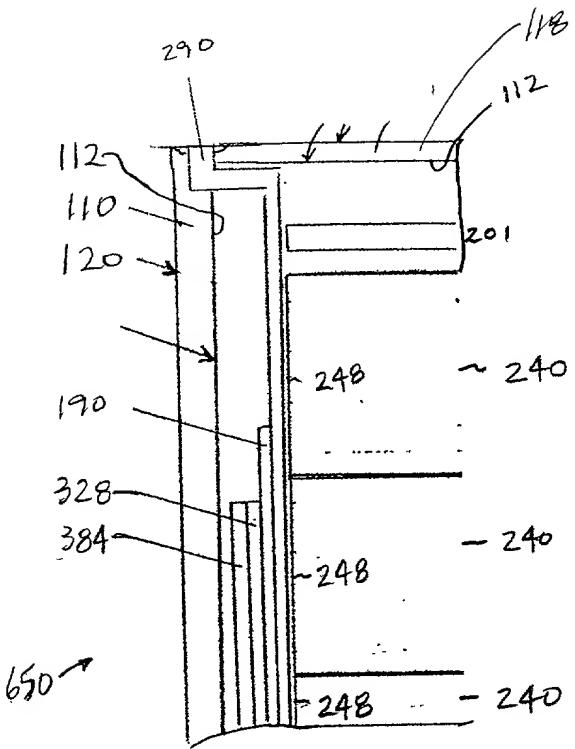


FIG. 15

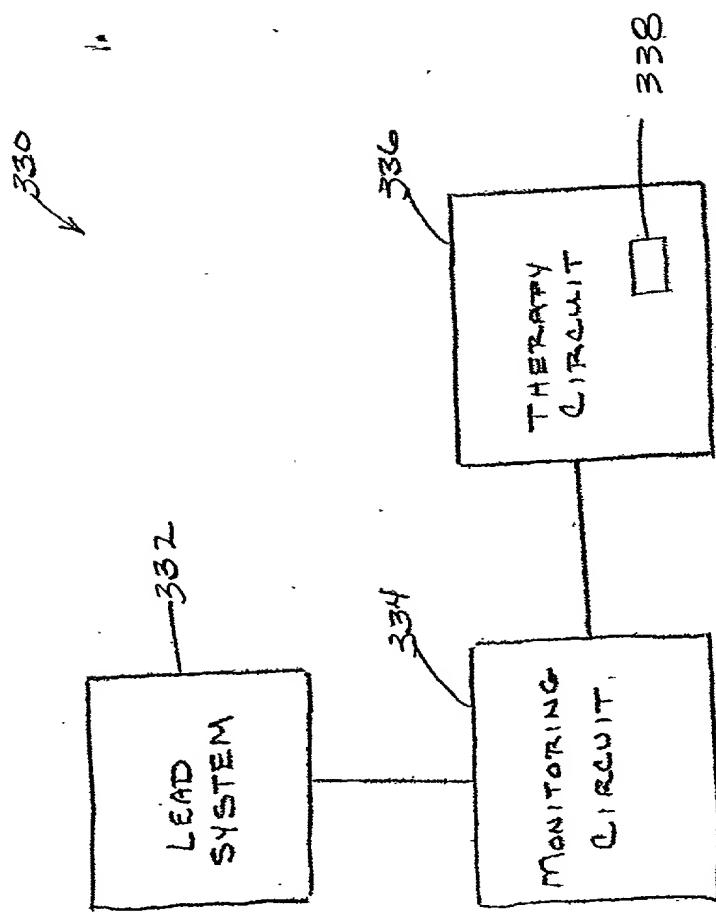


FIG. 16

SCHWEGMAN ■ LUNDBERG ■ WOESSNER ■ KLUTH

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: **FLAT CAPACITOR HAVING AN ACTIVE CASE.**

The specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. § 1.56 (attached hereto). I also acknowledge my duty to disclose all information known to be material to patentability which became available between a filing date of a prior application and the national or PCT international filing date in the event this is a Continuation-In-Part application in accordance with 37 C.F.R. § 1.63(e).

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 120 or 365(c) of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. § 1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

No such claim for priority is being made at this time.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

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Brennan, Thomas F.	Reg. No. 35,075	Kluth, Daniel J.	Reg. No. 32,146	Perdok, Monique M.	Reg. No. 42,989
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Clark, Barbara J.	Reg. No. 38,107	Lundberg, Steven W.	Reg. No. 30,568	Scott, John C.	Reg. No. 38,613
Clise, Timothy B.	Reg. No. 40,957	Maeyaert, Paul L.	Reg. No. 40,076	Smith, Michael G.	Reg. No. 45,368
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Camon, Owen J.	Reg. No. 36,143	Nama, Kash	Reg. No. 44,255	Woessner, Warren D.	Reg. No. 30,440
Harris, Robert J.	Reg. No. 37,346				

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/ firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Schwegman, Lundberg, Woessner & Kluth, P.A. to the contrary.

Please direct all correspondence in this case to **Schwegman, Lundberg, Woessner & Kluth, P.A.** at the address indicated below:

P.O. Box 2938, Minneapolis, MN 55402

Telephone No. (612)373-6900

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of sole inventor :

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Citizenship:

United States of America

Residence: **Oakdale, MN**

Post Office Address:

6895 Upper 28th Street North

Oakdale, MN 55128

Signature:

Michael J. O'Phelan

Date:

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) prior art cited in search reports of a foreign patent office in a counterpart application, and
- (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

- (1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or
- (2) It refutes, or is inconsistent with, a position the applicant takes in:
 - (i) Opposing an argument of unpatentability relied on by the Office, or
 - (ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

- (1) Each inventor named in the application;
- (2) Each attorney or agent who prepares or prosecutes the application; and
- (3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.